INSTRUCTION IN SCIENCE AND ART FOR WOMEN.

NOTES

OF FIFTEEN LECTURES

ON

"PHYSICS"

DELIVERED BY

PROFESSOR GUTHRIE,

IN THE

LECTURE-THEATRE

OF THE

SOUTH KENSINGTON MUSEUM

DURING

RY, FEBRUARY, AND MARCH
1870.

HB
27.8.96

LECTURES ON THE ELEMENTS OF PHYSICAL SCIENCE.

PHYSICS.

NOTES OF LECTURES.

LECTURE I.

1. When we describe a body we enumerate some of its properties.
2. The various properties of a body can be changed. That which effects the change is Force.
3. Thus the state or property of a body in regard to position is changed by Mechanical force such as Pressure. Its state in regard to temperature is changed by Thermal force or heat. And so on.
4. As many distinct properties as a body possesses, so many physical forces are there by which those properties are affected.
5. Matter has three forms, solid, liquid, and gaseous. These forms, however, are not perfectly distinct but merge into one another.
6. For the remainder of this lecture we are concerned only with mechanical force which we shall call simply force. A single force always produces motion when it acts upon a body which is at rest. Antagonism of forces may maintain rest or equilibrium.
7. Mechanics is the science which considers the effect of force upon the three forms of matter. It has subdivisions (1) according as the matter acted on is solid, liquid, or gaseous, and (2) according as it is at rest or moves under the action of the force or forces.

(*Mechanical*) *Force on Matter.*

Mechanics.

	Solids.	*Liquids.*	*Gases.*
Rest.	Statics.	Hydrostatics.	Pneumatics.
Motion.	Dynamics.	Hydrodynamics.	(Sound).

8. The *resultant* of two or more forces which act together on a body is the single force which, acting alone, would produce the same effect as the joint effect of the original forces. The original forces are *components* of their resultant.
9. Forces are represented by straight lines. The direction of the straight line represents the direction of the force: its length the magnitude of the force: and one of its ends the point at which the force acts.
10. When two forces act in the same straight line on a body their resultant is their sum or difference according as the forces act in the same or in opposite directions.
11. When two forces act upon a body in straight lines inclined to one another their resultant lies between them; its direction and magnitude are found by a simple geometrical construction.
12. A horse just keeping a carriage from rolling down a hill illustrates the equilibrium between three forces, namely: (1) the weight of the carriage: (2) the muscular strength of the horse: and (3) the pressure on the road.

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Lecture II.

1. If a load of bricks be raised from the ground to the roof of a building, the same amouut of *Work* is ultimately done, whether the bricks be lifted all at once, by hodsful at a time, or singly. If a hundred bricks are raised a hundred feet double as much work is done as when a hundred bricks are raised fifty feet or fifty bricks a hundred feet.

2. If a hundred bricks are raised one foot the same amount of work is done as when one brick is raised a hundred feet. The Unit of work is the work done when one pound weight is raised one foot.

3. A machine, properly so called, is an instrument for altering the magnitude, direction, or point of application of a force; but by no machine can the amount of "work done" be increased.

4. By means of a machine, a single brick *sinking* a hundred feet may be made to *lift* a hundred bricks one foot. This principle is exhibited on the lever, the wheel-and-axle, the pulley, and the wedge, etc. The "mechanical advantage" of a machine is the proportion between the two forces which keep one another at rest on the machine. The same proportion is obtained by comparing the *paths* of the points of application of the forces when the machine moves.

5. Hence the meaning of the expressions, "what is gained in power is lost in distance," and "what is gained in power is lost in time."

6. A liquid has less cohesion than a solid and assumes the shape of the vessel in which it is placed. It transmits pressure equally in all directions. The hydraulic press may be compared with a lever of unequal arms.

7. When a solid is plunged into a liquid a volume of liquid is displaced and lifted, equal to the volume of the solid. Hence, when a solid is in a liquid it will be pressed upwards by a force equal to the weight of the liquid it has displaced, that is by the weight of a volume of liquid equal in size to the body.

8. By this means it is possible to compare the weight of a body with the weight of an equal volume of water. Such comparison gives the "Specific Gravity" of the body.

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LECTURES ON THE ELEMENTS OF PHYSICAL SCIENCE.

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Lecture III.

1. Mechanical forces or pressures are conveniently represented and measured by weights. The weight of a body is the force with which it tends to approach the earth. This force varies with the size of the body with the nature of the substance of which it is made and with its distance from the earth.
2. The standard of weight is different in different countries and no two standards have a simple relation to one another. If the distance along the earth's surface from the equator to the pole be divided into ten-million equal parts each of those parts is a *metre* (between thirty-nine and forty inches): a tenth of a *metre* is a *decimetre*: a tenth of a *decimetre* or a hundreth of a *metre* is a *centimetre*. A cube of pure water at a certain temperature weighs a *gramme*.
3. It facilitates to such a degree the explanation of many facts to suppose that matter of all kinds consists of very small particles (of unknown size, shape, and weight) called *atoms*, which are not in contact with each other, that we shall assume such to be the case.
4. These atoms, in the case of solids are held together by a considerable force called *cohesion*. The cohesion of liquids is much less. In the case of gases it is inappreciable.
5. When the pressure on a gas is increased the volume of the gas is diminished. When the pressure is doubled the volume is halved. When the pressure is made three times as great the volume is made one third of the original size and so on. This is expressed by saying that the volume varies inversely as the pressure: the density varies with the pressure, being doubled when the pressure is doubled and so on.
6. The air has weight whereby it is held to the earth. Bodies on the earth are squeezed by the weight of the air above them. In deep mines this weight is sensibly greater,—on the tops of mountains sensibly less than at the sea level.
7. The air itself is squeezed by its own weight. Hence it is more dense at the earth's surface than above it. It may be likened to a compressed spiral spring. Its effort to expand is called its *tension*. Every square inch of surface is, at the sea-level, pressed upon to the amount of from fourteen to sixteen pounds. If a cylinder of one square inch bore be closed at one end and open at the other it will require a force of about fifteen pounds to drag a piston from the bottom of the cylinder. A *vacuum* will be formed between the bottom and the piston.
8. A *barometer* is such a cylinder; the piston is the mercury and the force is the weight of the mercury. If the bore of the tube be doubled, the pressure of the air is doubled but the weight of the mercury is doubled so that the height of the mercury remains the same (about thirty inches). The barometer, thus measuring the pressure of the air, may be used for determining the heights of mountains and for forecasting weather.
9. If the bottom of the cylinder in 7 be connected by a tube with a closed vessel containing air (which, like all air, is in a state of compression) the air will rush into the cylinder as the piston is pulled out. It will therefore occupy a greater volume or be rarefied. The *Air-pump* is a machine for repeating this rarefaction.
10. The *Suction-pump* and the *Siphon* also depend upon the pressure of the air.

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LECTURE IV.

1. A wave on the surface of a liquid is a travelling variation in height. A wave in a solid, liquid, or gas, is a travelling variation in density. When a series of waves travels along the surface of a liquid, there is a valley between each two hills and a hill between each two valleys. When a series of waves travels through a body there is a region of rarefaction between each two regions of compression, and a region of compression between each two regions of rarefaction.
2. A simple sound is the sensation produced upon the brain when the drum of the ear receives a wave or travelling variation in the density of the air. The waves themselves are commonly called sounds. In order that sound may be produced some elastic medium is necessary.
3. Sounds travel through the air at the rate of about eleven hundred feet a second. Very loud sounds travel faster than low ones. Sounds are reflected like surface waves. The loudness of a sound depends upon the degree of rarefaction and condensation which the air undergoes; that is upon the distance backwards and forwards through which a particle of air moves as the wave passes it. This distance is called the *amplitude* of the vibration.
4. When the same sound is repeated at regular intervals of time but more and more quickly, the ear becomes unable to distinguish between the individual sounds and a musical note is produced. In order that a musical note may be produced not less than sixteen vibrations must succeed one another in a second. As the number of vibrations is increased, the *pitch* of the note is raised. The highest audible note consists of about thirty-eight thousand separate sounds in a second. The range of notes employed in music lies between forty and four thousand vibrations a second.
5. Notes of the same pitch are said to be in *unison*. If, in the same time, the vibrations of the one are twice as numerous as of the other, the first is an octave higher than the second. Every alternate vibration of the first coincides with a vibration of the second. *Beats* are produced when the periods of augmentation of the one note by the other are distinguished. They take place at greater intervals according as the notes are more nearly in unison.
6. An elastic rod, fastened at one end, swings more slowly the longer and thinner it is. When a stretched string vibrates, the pitch of the note depends upon the tension of the string, its length, its thickness, and its density.
7. A rapid sequence of puffs of air may produce a musical note. In the *Syren*, notes of various pitch are thus produced, and the number of puffs in a given time can be measured.
8. The fundamental note of a string is the note produced by the vibration of the entire string. A stretched string may be made to vibrate in segments. The points between the segments are nearly at rest and are called *nodal* points or *nodes*. The notes then produced are higher according as the number of vibrating segments is greater.
9. When a body is set in vibration it rarely vibrates as a whole but in segments, between which are nodal points or lines. Powder strewn upon such a vibrating body will collect in these regions of comparative rest.
10. The same body, a rod, may vibrate across its length (transverse vibration), or along its length (longitudinal vibration). The one kind of vibration may be converted into the other.

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Lecture V.

1. Heat is the force which affects temperature. All known matter has heat. Matter receives heat when it becomes warmer: it gives out heat when it becomes colder. To get cold is to lose heat. Cold is the comparative absence of heat. Bodies of unequal temperature, when in contact, become of the same temperature, through the hotter losing and the colder gaining heat. Bodies are called warm or hot when they are hotter, cool or cold when they are colder than the blood.

2. The effect of heat on inanimate matter is perceived—(1) by its effect upon the size, shape, and physical state of the matter; (2) by the change it produces in colour; (3) by its influence upon magnetism, electricity, etc.; (4) by its chemical effect.

3. Heat is generally supposed to be a vibration of the atoms of matter.

4. The chief sources of heat are:—the internal heat of the earth; the heat of the sun; friction; compression; change of physical state; chemical union; electrical discharge; heat attending life.

5. All gasses expand by heat. A cubic foot of any gas at the temperature of melting ice becomes a cubic foot and three tenths and six hundredths at the temperature of boiling water. The air-thermometer measures change of temperature by change of volume of air. The fire-balloon and the trade winds are illustrations of the expansion of air by heat.

6. Liquids also expand by heat, but not all to the same degree. Water, as it is warmed from the temperature of melting ice, first contracts and then expands. The expansion of mercury by heat is made use of in thermometers to measure temperature. Solids also expand to various amounts when heated.

7. Bodies of the same temperature may have different *quantities* of heat, This arises from their having different *capacities* for heat. The proportion between the capacity of any weight of a substance for heat and the capacity of the same weight of water is the *specific heat* of the substance.

8. A body may receive heat without getting hotter. This takes place when the physical state of the body is changed, as when a solid melts or a liquid boils. The heat which thus changes (or accompanies the change of) physical state is said to become *latent*.

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Lecture VI.

1. Heat is required to melt a solid and to vaporize a liquid. When a solid melts it absorbs heat. When a liquid vaporizes it absorbs heat. The relation which heat bears to the three forms of matter is therefore this :—

Heat absorbed

$$\text{Solid.} \xrightarrow{\qquad} \text{Liquid.} \xrightarrow{\qquad} \text{Gaseous.}$$

$$\text{Solid.} \xleftarrow{\qquad} \text{Liquid.} \xleftarrow{\qquad} \text{Gaseous.}$$

Heat liberated.

2. When a liquid boils the elasticity or tension of its vapour overcomes the pressure of the air. If this pressure be diminished the liquid boils at a lower temperature. If the pressure be increased the liquid boils at a higher temperature.

3. Heat may pass from place to place by conduction, convection, or radiation. The best conductors of heat are solids: amongst solids, the metals: amongst the metals, silver. The best conductor of heat amongst non-metallic liquids is water. The best conductor amongst gases is hydrogen.

4. Convection can only take place in liquids and gases. Ventilation, winds, and ocean currents are instances of convection

5. The intensity of radiant heat diminishes as the distance from the source of heat increases.

6. When radiant heat falls upon a body it may be reflected, transmitted, or absorbed. Bodies which allow heat to enter with difficulty and are therefore good reflectors, allow heat to quit them with difficulty and are therefore good retainers or bad radiators. Smooth metallic surfaces are good reflectors. The path of the reflected heat makes the same angle with the reflecting surface as the path of the heat did which struck the surface.

7. Substances which allow heat to pass freely through them are called *diathermanous.* Diathermancy bears the same relation to heat that transparency does to light. Diathermanous bodies bend the course of the heat which enters them: this property makes it possible to concentrate transmitted heat upon one point or *focus.* A body may be diathermanous and opaque or athermanous and transparent.

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Lecture VII.

1. See notes 3, 4, 5, 6, and 7, of Lecture VI.

2. The heat produced by friction is proportional to the labour expended in overcoming the friction.

3. The "*mechanical equivalent*" of heat is the mechanical labour (work done) which, when expended in overcoming friction, would heat one gramme of water at 0° C. to 1° C.

Lecture VI.

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4. Convection can only take place in liquids and gases. Ventilation, winds, and ocean currents are instances of convection
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7. Substances which allow heat to pass freely through them are called *diathermanous.* Diathermancy bears the same relation to heat that transparency does to light. Diathermanous bodies bend the course of the heat which enters them: this property makes it possible to concentrate transmitted heat upon one point or *focus*. A body may be diathermanous and opaque or athermanous and transparent.

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Lecture VIII.

1. Light is emitted from all visible bodies. It may have its origin in the substance itself, which is then luminous: or the visible substance may reflect the light from other sources. The sun and the flame of a candle are instances of the first kind: the moon and most substances are instances of the second kind.

2. The chief sources of light are:—the sun:—the light accompanying chemical change:—the light caused by electrical discharge. All substances when very much heated give out light. At the same high temperature, solids are more luminous than liquids, and liquids than gases.

3. Light, like heat, may linger in certain bodies after the source of light is withdrawn. Such bodies are called phosphorescent.

4. Light travels at the rate of about two-hundred million miles in a second. That its path is straight is shown by the position of shadows. The intensity of the light which falls upon a body from a constant source varies inversely with the square of the distance of the body from the source of light.

5. A band of light taken in the direction of the light's motion is called a *beam*; an exceedingly narrow beam is a *ray*.

6. If a ray of light strike a reflecting surface, it makes the same angle after reflexion as it did before. The ray before reflexion, the ray after reflexion and the perpendicular to the surface are all in one plane.

7. When the light which a body gives out enters the eye, the body *appears* to be in the direction of the light which enters the eye.

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Lecture IX.

1. It follows from the law of reflection that when an object is seen in a plane mirror it appears to be as far behind the mirror as it is in reality before it.

2. When a ray of light passes the boundary surface between two media, the direction of the ray is altered. Such alteration is called *refraction*. The amount to which a ray of light is refracted when it passes from one medium into another, depends upon the nature of the medium which it leaves and also upon that of the medium which it enters. The power of refracting the ray is represented by the *refractive index* of the substance.

3. If a ray pass from the air into glass it is, on entering the glass, bent towards the perpendicular to the glass's surface. If the ray pass from glass into air it is bent from that perpendicular.

4. If the surface of a piece of glass be properly curved, rays which enter on one side may be so refracted that they all meet in one point after quitting the glass on the other side. Such a piece of glass is a *lens* and the point at which the rays meet is its *focus*. According to the shape of the lens converging rays may be made parallel, parallel rays may be made to diverge and so on.

5. A true optical image is a collection of foci each of which corresponds to a point of the object.

6. The eye is a dark chamber full of liquid and semi-liquid transparent matter which, acting like a lens throws images upon the nerves at the back of the eye. The collection of nerves which receives the image is the *retina* and the impression on the retina is vision.

7. Long and short sight result from the image not falling exactly upon the retina.

8. The image of a bright object excites portions of the retina in the neighbourhood of those upon which the image itself falls. This gives a greater apparent size to the bright object than that which it actually possesses. *Irradiation* is the name given to this effect.

9. The eye retains for a time the impression of an image.

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Lecture X.

1. If a beam of white light, such as that of the sun or of the electric lamp, is refracted, the refracted beam is found to consist of variously coloured rays. These can be distinguished from one another because, being refracted to different degrees, they are separated.
2. A glass prism effects such separation of the coloured rays which constitute white light. The series of colours into which the white light is thus separated is called the *spectrum*.
3. These coloured rays may be reunited by means of a second prism into a white beam. Such recomposition is called ***synthesis***.
4. By light of a certain colour we may understand light of a certain *refrangibility* (i.e. which is refracted to a certain degree). Thus red rays have the least, and violet the greatest refrangibility.
5. Colourless transparent substances allow all the coloured rays to pass through them: white opaque substances reflect all the coloured rays which strike them. Coloured transparent substances only allow certain of the coloured rays to pass through, they absorb the remainder. Coloured opaque substances reflect certain of the coloured rays and absorb the remainder. The colour of a substance depends therefore upon the colour of the light which it receives, and also upon the colour of the light which it absorbs. Thus, a blue transparent substance will allow no red rays to pass through: if it only receive red rays it will allow no light to pass through. A red opaque substance is one which reflects only red rays. If it receive only yellow rays it will reflect no light and will therefore appear black.
6. If the spectrum of the sun's light be examined it is found to be traversed by innumerable black lines, showing that at every such part there is no light; or light which has that particular refrangibility is absent.
7. The vapour of a substance absorbs the same light (light of the same degree of refrangibility) as the incandescent substance itself gives out. Thus incandescent compounds of sodium give rise to yellow light. This is shown by a yellow band in the spectrum. The vapour of sodium absorbs this yellow light. So that the yellow band in the spectrum of light in which sodium is heated is replaced by a black band when the light of the spectrum passes through the vapour of sodium.
8. It is supposed that the black lines seen in the solar spectrum are caused by the absorption in the Sun's atmosphere of rays of certain refrangibility. By comparing the positions of these black lines with the positions of the coloured bands due to incandescent metals it is concluded that certain metals are present in the Sun.

Note.—*Erratum.* In Lecture VIII. for "two hundred million miles a second," read "two hundred thousand miles a second."

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Lecture XI.

1. Whenever two unlike substances are rubbed together both of them acquire the power of attracting other bodies. Glass which has been rubbed with tinned silk, and sealing wax which has been rubbed with flannel show this power of attraction very distinctly.
2. Glass which has been rubbed with tinned silk *attracts* sealing wax which has been rubbed with flannel. Glass which has been rubbed with tinned silk *repels* glass which has been rubbed with tinned silk. Sealing wax which has been rubbed with flannel *repels* sealing wax which has been rubbed with flannel.
3. Hence it seems that there are two kinds of electricity: namely, that observed in the rubbed glass, and that observed in the rubbed wax. These are called *vitreous* and *resinous* electricities: also positive (+) and negative (—). Vitreous is called positive (+): resinous is called negative (—).
4. Similarly electrified bodies repel one another; dissimilarly electrified bodies attract one another. The gold leaf electroscope is an instrument for showing the presence of an excess of either kind of electricity by the divergence which the electricity causes between two gold leaves hung side by side.
5. It is supposed that the electricity produced by friction is not created by that act, but that a body in the ordinary state contains equal quantities of the opposite kinds of electricity which therefore neutralize one another. By friction this neutralized electricity is decomposed, the vitreous or positive being then found in excess on one of the bodies rubbed, the resinous or negative on the other. It is in fact found that when two bodies are rubbed together they acquire opposite electricities.
6. The metals are the best conductors of electricity: those metals conduct electricity best which conduct heat best. Silk, glass, resin, sulphur, gutta-percha, are bad conductors. Hence their use in shewing electrical effects: for the electricity on one part of them will not readily escape along them to the ground.
7. When an electrified body is brought into the neighbourhood of a neutral one, the electricity of the neutral body which is opposite in kind to that of the electrified one is held or bound, and the electricity of the neutral body of the same kind as that of the electrified one is disengaged. The electricity thus disengaged is said to be *induced*.
8. A body connected with the earth by a good conductor forms a source for an unlimited supply of electricity.
9. The *electrophorus* may be considered as an electric pump for pumping electricity out of the earth. Its action depends upon the inductive decomposition of successive portions of the earth's electricity by the same quantity of electricity of one kind situated on a non-conductor.

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Lecture XII.

1. Substances may be arranged in the order of their electrical tension; that is, in such an order that if any two substances be rubbed together, the one nearer to the head of the list will show positive electricity. The structure of the body's surface may however affect its place in such a list.
2. The action of an electrical machine depends upon the continual analysis of the earth's electricity. That analysis takes place at the surface of contact between tinned silk and glass. The negative electricity of the tinned silk is neutralized by the positive electricity ascending from the earth. The positive electricity of the glass is continually removed from the glass to which it clings and with which it moves.
3. An insulated body (one supported by a non-conductor) in the neighbourhood of the earth may receive a large amount of electricity of one kind (say +) without showing its presence, because the opposite kind (—) of the earth's electricity holds it in check (induction). If the body so charged be removed from the neighbourhood of the earth, the excess of electricity is manifested. Such accumulation of electricity is called *condensation.*
4. If a surface of metal connected with the earth be separated by a non-conductor from another surface of metal, which is thereby insulated, the second surface may receive a large charge of electricity because such electricity is held in check and condensed by the earth's opposite kind of electricity. This is the principle of the *Leyden Jar.*
5. If the inner and outer coatings of a charged Leyden jar be removed, the electricity is found not on the metallic surfaces but on the glass surfaces. A portion of it appears indeed to penetrate some distance into the glass and to escape therefrom to the surface after the jar has been discharged. Such electricity is called *residual.*
6. If an insulated body of irregular form receive a charge of electricity, the latter is not distributed uniformly over the body's surface. It accumulates on convex surfaces in preference to concave ones, and on surfaces of greater curvature in preference to surfaces of less.
7. If the surface electrified have a sharp point, the accumulation of electricity may be so great as to escape by that point into the surrounding air which therefore becomes similarly electrified: repulsion follows.
8. Though the impression of the spark lasts for some time on the retina, the duration of the spark is inappreciably small.
9. The nature of the electric discharge depends upon the nature of the medium through which it takes place.

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LECTURE XIII.

1. If the ends of two pieces of unlike metals be placed in a liquid which attacks the one and not the other, and if the metals outside the liquid be connected by another piece of metal, the connecting metal is found to acquire certain new properties which are due to the passage through it of a kind of electricity (called *voltaic* or *galvanic*) different from that got by friction.
2. By increasing the number of pairs of pieces of dissimilar metals and connecting by metal wires the unlike metals of the intermediate pairs, the galvanic current which passes through a wire connecting the extreme pieces of metal may be increased in strength. Such an arrangement forms a *galvanic battery*, of which the extremes are the *poles*.
3. The metallic connection of the extremities or *poles* of a battery attracts iron filings. It affects the magnetic needle (compass needle) turning it one way when above the needle and the other way when below. The direction of deflexion of the needle is also altered if the current be reversed, that is if the attachments of the connecting wire to the battery be exchanged so that the end of the wire which was fastened to the zinc is fastened to the platinum and *vice versa*.
4. A galvanic current is also produced when the temperature at the point of contact between two unlike metals is changed, provided that the other ends of the dissimilar metals are connected by a metal (*Thermo-electricity*: the *Thermo-multiplyer* or *pile*.)
5. If the conducting connector be imperfect either through being in nature an imperfect conductor or through being too thin, it becomes hot. If the circuit be interrupted by a very narrow interval, the electric current may pass over that interval provided it can tear off and carry with it particles of the circuit. Such particles may get so heated as to give out light. The electric light may be produced *in vacuo* or under water.
6. If the two poles of a battery are brought into a liquid (which is not a metal) the liquid is very often decomposed. The parts into which it is decomposed are found on the poles and are *characteristic* of those poles.
7. The process of electro-plating depends upon such systematic analysis of liquids containing metals.
8. A current passing along a wire in one direction will give rise to a current passing in the opposite direction in a parallel neighbouring wire. The second is called the *induced* current.
9. Two currents passing along parallel wires in the same direction attract one another. If they pass in opposite directions they repel one another.
10. A current passing in a spiral round a bar of soft iron converts the iron for the time into a magnet.

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Lecture XV.

1. As far as is at present known, the Universe seems to consist of between sixty and seventy different and distinct substances called *elements*. These are as different from one another as are the notes of a musical instrument or the letters of an alphabet. By combining musical notes in various sequences an incalculable number of tunes may be produced. By combining different letters of the alphabet in different sequences to form words, and by combining those words in different sequences an incalculable number of ideas may be expressed. The chemical elements may be compared with the notes of music or the letters of the alphabet.
2. So that when we examine any substance in order to ascertain of what elements it consists, we find that it is either an element or a compound of more than one element.
3. *Analysis* is the separation of a substance into its constituents. Ultimate analysis is the separation of a substance into its elements. Synthesis is the chemical union of the elements or their compounds with one another.
4. When two elements or compound bodies are physically mixed, the properties of the mixture are intermediate between those of the constituents. When chemical union occurs the resemblance between the product and the constituent is often disguised. Also when a substance is analysed the products or constituents may bear but little resemblance to the parent substance.
5. When elements or compounds simply mix no heat is liberated. When chemical union takes place heat is liberated.
6. Chemical union only takes place between definite proportions of the different elements. It is convenient to attribute this *fact* to the *hypothesis* that one kind of matter (one element) consists of atoms, innumerable but of equal weights: and that the weights of the atoms of another element are equal to one another but different from the weights of the atoms of another element.
7. The physical forces bear such a relation to one another that the disappearance of one is accompanied by the appearance of another.

Books recommended for further study:

Ganot's Physics. Edited by E. Atkinson. H. Ballière, Regent Street. 15s.
Tyndall on Heat considered as a mode of motion.
Longmans, Paternoster Row. 12s.
B. Stewart on Heat. Macmillan, Bedford Street, Covent Garden. 7s. 6d.
Tyndall on Sound. Longmans.
Guthrie on Heat and Non-Metallic Chemistry.
Van Voorst, Paternoster Row. 7s. 6d.